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FACTOR ANALYSIS ON INNOVATION INDUCTORS IN HIGH PERFORMANCE ORGANIZATIONS

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ABSTRACT

There are several awards and models of quality and innovation applied around the world. The problem studied is that many organizations present different dimensions and scales for the evaluation of organizational innovation and analysis for the innovative recognition of companies. The article aims to present, through the exploratory and confirmatory factorial analysis, the main inducing factors of organizational innovation in a set of 19 Brazilian companies, from the public and private sectors, with nationally recognized performance. The research integrates the methodology of evaluation of awards, norms and models of innovation - APMNI. The research is characterized as mixed approach (qualitative and quantitative) through data collection with interviews and survey, submitted to content analysis and multivariate statistics. The results indicate that all factorial models (2, 3, 4, 5 and 6 factors) were consistent in light of the statistical analysis. The results indicate that all factorial models (2, 3, 4, 5 and 6 factors) were consistent with statistical analysis. It is concluded that the most adequate explanatory model was the one with four inducing innovation factors: PD&I Management Model; Top Management; Innovation Culture and Innovation Strategies.

Keywords: Innovation; Factor Analysis; Inducing Innovation Factors; PD&I Management Model; Top Management; Innovation Culture and Innovation Strategies.

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ANÁLISE FATORIAL DOS INDUTORES DE INOVAÇÃO EM ORGANIZAÇÕES DE ALTO DESEMPENHO

RESUMO

Existem diversos prêmios e modelos de qualidade e inovação aplicados pelo mundo. A situação-problema estudada é que várias organizações apresentam dimensões e escalas diferentes para avaliação da inovação organizacional e análise para o reconhecimento inovador das empresas. O artigo tem como objetivo apresentar, por meio da análise fatorial exploratória e confirmatória, os principais fatores indutores da inovação organizacional em um conjunto de 19 empresas brasileiras, das esferas pública e privada, com desempenho reconhecido no cenário nacional. A pesquisa integra a metodologia de avaliação de prêmios, normas e modelos de inovação - APMNI. A pesquisa caracteriza-se como abordagem mista (qualitativa e quantitativa) por meio de coleta de dados com entrevistas e *survey*, submetidas à análise de conteúdo e estatística multivariada. Os resultados indicam que todos os modelos fatoriais (2, 3, 4, 5 e 6 fatores) foram consistentes à luz das análises estatísticas. Conclui-se que o modelo explicativo mais adequado foi o com quatro fatores indutores de inovação: Modelo de Gestão de PD&I; Alta Direção; Cultura da Inovação e Estratégia para Inovação.

Palavras-chaves: Inovação; Análise Fatorial; Fatores Indutores Da Inovação; Modelo de Gestão de PD&I; Alta Gestão; Cultura da Inovação e Estratégia para Inovação.

INTRODUCTION

Innovation, a construct from Economics, has been explored by other scientific fields, namely Engineering, Sociology and Administration, and according to Schumpeter (1997), it has been considered as an inductor for economic and social development, being essential to increase the competitiveness of organizations.

OECD (2005) defines innovation as an introduction of goods or services that are new or had been sharply improved regarding their characteristics or uses. Currently, the systematized practice of promoting improvements with added value recognized by stakeholders is no longer a privilege of some countries, sectors of the economy and large-scale organizations. More relevant than seeing innovation as a new or improved product is to notice if the organization has a culture oriented for innovation. Innovation includes the search, the discovery, experimentation, development, imitation and the adoption of new products, services, processes and new organizational techniques, similar to the concept proposed by Dosi (1982). Innovation is observed in final characteristics of products and services, as the result of mobilization of technical capacity, skills of suppliers and clients during services.

The organizational environment, when focused on innovation, tends to be open to new ideas and to change through new technologies, resources, abilities and administrative systems (Zhou, Yim e Tse, 2005). In this context, the research that originated the article is inserted, aiming to confirm the inductors factors of innovation that exist in the organizational environment of high-performance organizations, considering management practices driven to innovation.

When evaluating the environment of the organization, the adherence of the management structure to assimilate organizational innovations is investigated, observed as the implementation of practices of management, processes, structures or new techniques that favor to reach strategic goals (Birkinshaw, Hamel and Mol, 2008).

For the literature review, search was performed in: *SAGE Journal on Line, Capes, Proquest, Scielo, Web of Science, B-On, Scopus and Emerald*, with innovation and innovation management as keywords. To build the sample of manuscripts, the following criteria were adopted: (a) involving innovation management associated to management models; (b) constituting an empirical research report and (c) had been published from 2008 to 2016. The 19 manuscripts were chosen according to the scope of the research, and they were put together with other texts that are considered classic in the innovation field, totaling 34 publications. Table 1 indicates this distribution.

Table 1. Taxonomy of empirical manuscripts about innovation published between 2008 and 2016

Themes	Amount	%
Innovation management model	13	38
Innovation in services	7	21
Innovation capacities	6	18
Innovation in the public sector	5	15
Organizational innovation	1	3
Predecessors of innovation	1	3
Technological innovation	1	3
T O T A L	34	100

Source: elaborated by authors.

Major gaps identified in the literature review are related to difficulties to measure innovation, mainly regarding organizational innovation adopted in the service sector, according to Gallouj & Weinstein (1997) and Gallouj (2002). There are only a few articles dedicated to investigate the public sector.

Research problem and objective

Based on the need of systematization and innovation management in services (SUNDBO, 1997), the following question appears: what are the major inductors of organizational innovation?

Based on exploratory and confirmatory factorial analysis, this research aims to present the main inducing factors of organizational innovation in a set of 19 Brazilian companies, from the public and private spheres, with nationally recognized performance. The research integrates the methodology of evaluation of awards, norms and models of innovation - APMNI. The APMNI methodology was created at Technical Innovation Center, of National Foundation of Quality (FNQ), in Brazil, to spread the innovation management concept to Brazilian organizations and universities. The technical center, coordinated by FNQ and Fundação Getúlio Vargas, is composed by: AES Brazil, Ampla, Brasilata, Cemig, Coelba, Correios, Cummins, EDP, Embraer, FGV, Fibria, Fleury, GPC Química, Itaú, Natura, Promon, Senac, Senai and Volvo.

THEORETICAL FOUNDATION

Innovation

Innovation may be conceived as the transformation of an idea into a new product,

process or even as the use of a new resource in practices of the organization, adding value to stakeholders. OCDE (2005) and BSI (2008) share these concepts. Moreover, Birkinshaw, Hamel and Mol (2008) classify as radical the one that results in products or processes that are significantly new, and as incremental those who present progressive improvements of characteristics.

These authors indicate some perspectives of innovation in the area of organizations, namely: institutional, cultural and rational. The first one considers institutional and socioeconomic conditions where innovations emerge, allowing progressive changes in management practices and the insertion of new processes of work.

The second focuses on understanding the way that cultural assumptions absorb the organizational innovation, imposing or surpassing the limits of its adoption and dissemination. The third perspective sees the role of the entrepreneur as essential for the innovative performance of the organization, where improvements are introduced and carried out by individual efforts or teams and then spread to other areas.

Considering this literature review, a set of international research that had investigated predecessors of organizational innovation (Chen, Tsou and Huang, 2009; Gebauer, Krempl, Fleisch and Friedli, 2008; Jong and Vermeulen 2003) is observed.

Results indicate 15 factors or predecessors of innovation: the involvement of frontline workers; information sharing; multifunctional teams; tools; information technologies; internal organization; education; presence of service excellence; autonomy of employees; market research; market test; strategic focus; external contacts; resource availability and management support.

Danilevicz and Ribeiro (2013), who understand innovation as a complex and multifaceted process, developed a quantitative model for innovation management that structures and evaluates the ideation process and identifies the potentiality of innovation and competitiveness in processes and products, generating an innovation index practiced by the organization. These authors defend that the systematization of the structured innovation process induce to strategic decisions associated to the development of new products.

Hashi and Stojčić (2012) investigated, in European organizations, the impact of innovation in the company's performance. Results indicate a significantly positive relationship between innovation and performance. Moreover, the size of the organization and the economic scenario present a difference of behavior in organizations with mature economies or in development. The BS-7000-1 British standard (BSI, 1999) indicates that activities that are inherent to innovation lead organizations to improve their standards in order to increase the competitiveness level and create stability in the relationship between stakeholders. Birkinshaw, Hamel and Mol (2008) also follow this idea.

Resende Junior, Pinheiro and Valeri (2015) identified, through qualitative research, four explanatory categories for the innovative performance in high-performance Brazilian organizations: a) Process Performance for Innovation; b) Leadership for Innovation; c) Class 3: Learning for Innovation and d) Class 4: Requirement Management for Stakeholders.

The first one is characterized by the demonstration of strategic capacity of the organization to obtain current levels of performance through developing and implementing new products, services and processes, with the significant presence of mechanisms to measure results of innovation and innovation efforts.

The second, related to the size of Innovation Governance, presupposes that high administration operates directly in the creation and dissemination of the innovation culture, through the maintenance of an environment of creativity, knowledge sharing and corporate entrepreneurship. The third refers to the ability of critically analyze the results of the PD&I system, considering the process of ideation and experiences that come from the practice of open innovation and co-creation with the stakeholders. Lastly, the Requirements Management indicates that the PD&I policy

needs to guarantee the existence of systematized processes of necessities analysis, expectations and requirements of the stakeholders in the organization.

METHODOLOGY

The research used a mixed approach (qualitative and quantitative) of collecting and analyzing data. Initially, the literature review was performed (both national and international), using books and journals with high impact in the Administration field.

This article focuses on the four stages of the empirical section of the APMNI methodology described on Figure 1: research preparation; theoretical research; empirical research and evaluation of results (Resende Junior and Fujihara, 2015).

The full development requires accomplishing 22 stages, and its modular implementation is allowed. In this manuscript presents the results of stages 14 and 15.

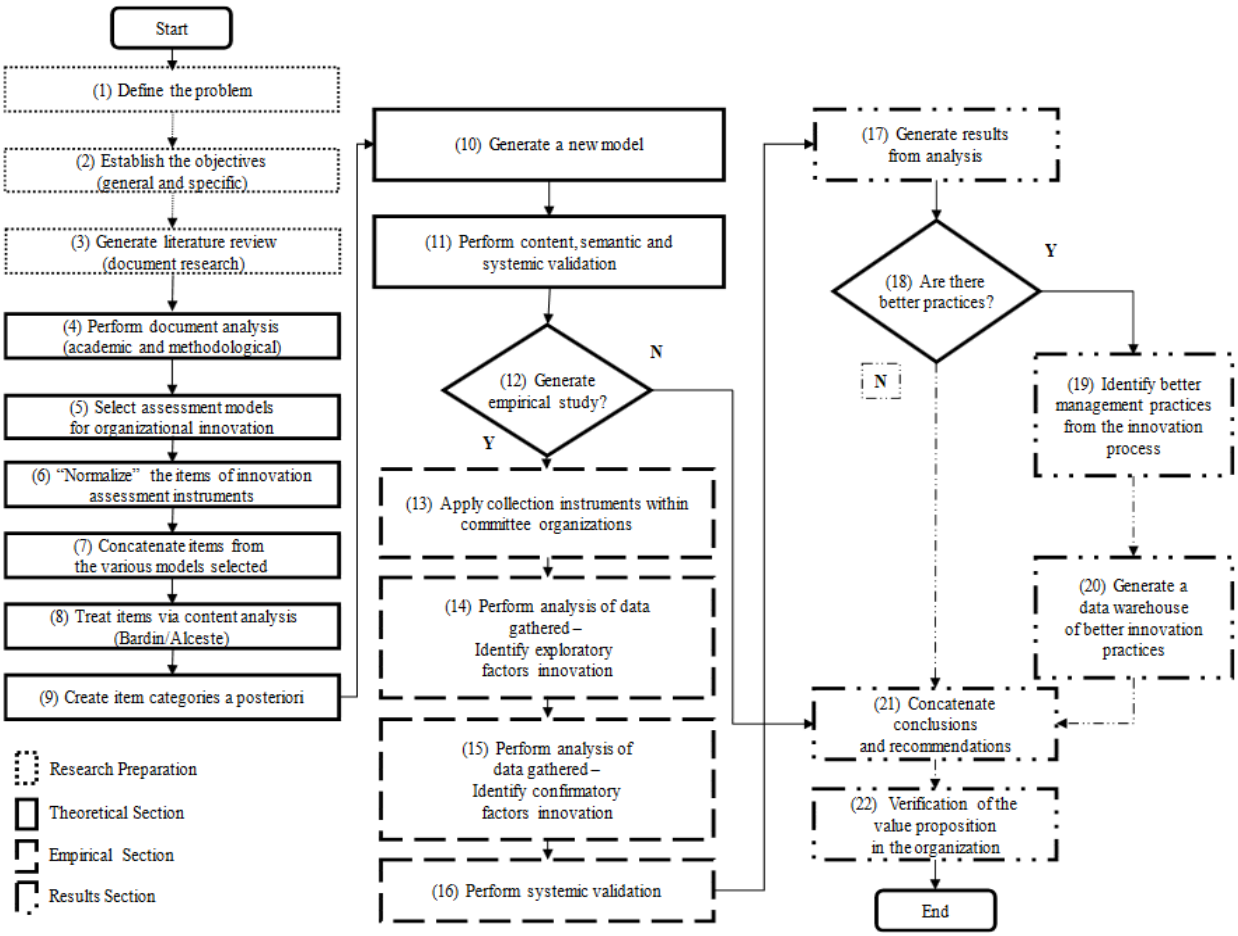

Figure 1. Stages of innovation models evaluation methodology.
Source: Resende Junior and Fujihara (2015).

Elaboration of instruments and data gathering

In order to elaborate items of the scale, it was used: a) document analysis, reading references of each model, norm and award identified; b) interviews with specialists and c) descriptions of characteristics of organizations that encourage or are prone to innovation. Validations of content, semantic and systemic of the questionnaire items were performed according to criteria suggested by Hernandéz-Nieto (2002), Pasquali (2010) and Hair, Anderson, Tatham and Black (2009), aiming to guarantee that every measure item indicates an observable action, explicit and clear, considering social variables of the environment or requested resources for the object of the action.

In the stage of validating the content by judges, according to Hernandéz-Nieto (2002), judges were understood as specialists in the field of the investigated phenomenon with knowledge to validate the construct and the context researched. The goal of the content validation is to confirm, theoretically, the hypothesis that items represent adequately the construct, consisting in asking for opinions, from people who are not yet a representative sample of the population, to construct such an instrument (Pasquali, 2010).

To measure the Content Validity Coefficient (CVC) of each item of the questionnaire, each judge rated from 1 to 5: 1 represents “very little”; 2, “little”; 3, “average”; 4, “much” and 5, “very much”. The items evaluated (1, 2 and 3) were: 1) Transparency of the language: to check if the language is clear and adequate enough for the profile of organizations sample in the research; 2) Practical relevance: to evaluate if the item is pertinent for the profile of the research sample and 3) Relevance for Innovation, to check if the item is representative to measure the phenomenon.

The initial tool developed from the literature review and qualitative data gathering was composed by 180 items. After the first round of validation by judges, 131 items were left. The final validated instrument was applied with 65 items to 335 respondents. Data were treated following the technique of Exploratory Factorial Analysis using the software IBM-SPSS 19.0, and the Confirmatory Factorial Analysis, using IBM-SPSS AMOS 22.0.

ANALYSIS RESULTS

Exploratory Factorial Analysis

During exploratory factorial analysis, all tests were run to verify theoretical hypothesis in order to define characteristics of matrix and possibilities of factorability. In the correlation matrix the size of correlation coefficients was examined and it was verified that almost 100% of values are higher than 0.3 and the correlation average surpassed 0.5, indicating that the matrix is factorable, according to Hair et al.

KMO and Bartlett's test for sphericity were also performed. The matrix indicated KMO = 0.977, higher than 0.7 (Hair et al, 2009), representing high capacity of factorability, while Bartlett’s index was 25607.904 with p-value<0.05 (Hair et al., 2009), indicating low probability that the population matrix is an identity matrix. Communalities for 65 variables that composed the final instrument were evaluated, in order to measure the variable regression index, considering each one of them as a dependent variable and others as independent variables. Extreme values were not identified; therefore, the analysis of this hypothesis was positive, and problems with communalities were not observed.

In order to perform initial estimates of the number of factors, the Principal Component Analysis was performed, aiming to verify the explained variation and *eigenvalues*. In the evaluation provided by *eigenvalues*, the data basis indicates the existence of up to six factors.

In Table 2, Total Variance Explained, the amount of own values or autovalues (*eigenvalues*) is higher than 1. Another analysis

is the variance explained by the factor, which should be at least 3%. *Eigenvalues* are the total of the column of factorial load squared to a factor, known as latent root. It represents the amount of variance explained by a factor. By the explained variance we would have two factors in the example. The *eigenvalues* analysis, in turn, indicates the existence of up to six factors. By analyzing the scree plot graphic, the basis could present up to three factors.

Table 2. Explained variation of components

Components	Initial Eigenvalues			Extration Sums of Squared Loading		
	Total	% variance	% cumulative	Total	% variance	% cumulative
1	41.083	63.204	63.204	41.083	63.204	63.204
2	2.279	3.506	66.711	2.279	3.506	66.711
3	1.827	2.810	69.521	1.827	2.810	69.521
4	1.573	2.419	71.940	1.573	2.419	71.940
5	1.131	1.740	73.680	1.131	1.740	73.680
6	1.094	1.682	75.362	1.094	1.682	75.362

Source: Research data.

Aiming to generate congruence between the analysis of factorial loads and the theoretical sense of potential factors, the model with six factors was investigated, and the model can explain up to 75.36% of the phenomenon.

Explanatory models with 6, 5, 4, 3 and 2 factors were tested. In the six-factor model, all 65 variables present factorial charge higher than 0.3, the minimum acceptable according to Hair et al. (2009) and the theoretical sense of grouping the following factors was observed: High Direction; Innovative Capacity; Innovation Culture; Strategy for Innovation; Ideation and Networking.

Cronbach's Alpha was calculated to evaluate the internal consistency of the factors and all of them were considered excellent, according to Hair et al. (2009). Table 3 shows the results.

Table 3.
Internal consistency of the six-factor model

Six-factor model	Cronbach's Alpha	Amount of variables
Factor 1 – High Direction	0.985	21
Factor 2 – Innovative Capacity	0.958	15
Factor 3 – Innovation Culture	0.972	17
Factor 4 – Strategy for Innovation	0.856	3
Factor 5 – Ideation	0.922	4
Factor 6 – Networking	0.933	5

Source: Research data.

The same analysis was performed for other models that presented both adequate factorial charges and Cronbach's Alpha, according to results described on Tables 4, 5, 6 and 7:

Table 4.
Internal consistency of the five-factor model

Five-factor model	Cronbach's Alpha	Amount of variables
Factor 1 – High Direction	0.985	21
Factor 2 – Innovative Capacity	0.970	20
Factor 3 – Innovation Culture and Organizational Learning	0.971	16
Factor 4 – Strategy for Innovation	0.855	4
Factor 5 – Ideation	0.922	4

Source: Research data.

Table 5.
Internal consistency of the four-factor model

Four-factor model	Cronbach's Alpha	Amount of variables
Factor 1 – PD&I Management Model	0.974	22
Factor 2 – High Direction	0.983	20
Factor 3 – Innovation Culture	0.968	17
Factor 4 – Strategy for Innovation	0.896	5

Source: Research data.

Table 6.
Internal consistency of the three-factor model

Three-factor model	Cronbach's Alpha	Amount of variables
Factor 1 – PD&I Management Model	0.975	24
Factor 2 – High Direction	0.982	19
Factor 3 – Innovation Culture	0.974	22

Source: Research data.

Table 7.
Internal consistency of the two-factor model

Two-factor model	Cronbach's Alpha	Amount of variables
Factor 1 – Leadership	0.987	34
Factor 2 – PD&I Strategy	0.977	26

Source: Research data.

All models presented consistent results, leading to the confirmatory factorial analysis for a more detailed statistical analysis.

Confirmatory Factorial Analysis

In order to perform the confirmatory factorial analysis, the maximum likelihood estimator was used, with structural equation modeling, according to the software AMOS – IBM SPSS 18.0. Aiming to evaluate the models, the following indexes were used: a) Chi-square and the ratio of chi-square ($\chi 2$) to degrees of freedom (df) - (CMIN/DF) – The $\chi 2$ indicates the discrepancy between modeled and observed covariance matrix, in which the probability of the theoretical model adjusting to data is tested.

However, it is more common to consider degrees of freedom (χ2/df), and values may be between 1 and 3 (Kline, 2005); b) CFI (Comparative Fit Index) and TLI (Tucker Lewis Index) calculate the adjustment of the model observed with a basis model. It is expected to obtain values above 0.9 to indicate an adequate adjustment (Bentler, 1990; Hu & Bentler, 1999).

The more the value nears 1.0, the better the adjustment (Fife-Schaw, 2010); c) RMSEA (Root-Mean-Square Error of Approximation) also relates to the discrepancy of matrix regarding the population.

The best result may be below 0.05 (Kline, 2005); however, if it is between 0.06 and 0.08, it is considered an adequate adjustment (Finch & West, 1997); d) SRMR (Standardized Root Mean Square Residual) represents the standard average of residues.

Indexes that are below 0.1 indicate a good adjustment (Hair and cols., 2009; Kline, 2005); e) NFI (Normed Fit Index): compared the chi-square with the model tested against chi-square for the base model. Values higher than 0.95 are expected (Bentler, 1990; Thompson, 2004); and f) GFI (Goodness-of-fit Index) – due to the sensitivity of this index, it has become less popular and recommended not to be used (Sharma et al., 2005).

Five confirmatory factorial analyses were generated from the models proposed by Resende Junior, Oliveira and Fujihara (2016).

Confirmatory Factorial Analysis for the six-factor model

According to Table 8, for the AFC of six factors, results revealed: CMIN/DF = 2.24; CFI = 0.917; RMSEA = 0.064; SRMR = 0.0392; GFI = 0.728; AGFI = 0.694 and TLI = 0.909. The SRMR is at an adequate level (< 0,10), favoring the acceptance of the model. Although it does not present the best result (<0.05), the RMSEA indicated an acceptable adjustment of the structure, considering a value below 0.08 (Finch & West, 1997).

CIF and TLI did not present adequate values considering the acceptable parameter higher than 0.90. Although the GFI index did not present a result below 0.9, due to the sensitivity of it, it has become less popular and recommended not to be used (Sharma et al, 2005).

Confirmatory Analysis for models with 5, 4, 3 and 2 Factors

When comparing the models, it is observed in Table 8 that indexes presented favorable results for the acceptance of all models. The four-factor model presented well-adjusted results, although they are very similar to other models.

Table 8. Comparative of models

Measure	2 Factors	3 Factors	4 Factors	5 Factors	6 Factors	Recommended values	Reference
Absolute Measure							
χ2 (chi-square)	1805.95	2440.69	1743.91	3359.41	3168.93	p-value > 0.05	Hair et al. (2009)
GFI (Goodness-of-fit Index)	0.755	0.759	0.796	0.721	0.728	> 0.9	Jöreskog, & Sörbom (1993),
RMSEA (Root-Mean-Square Error of Approximation)	0.071	0.065	0.063	0.067	0.064	< 0.08	Hair et al. (2009)
SRMR (Standardized Root Mean Square Residual)	0.0395	0.0355	0.0332	0.0393	0.0392	< 0.08	Brown (2006)
Incremental measure							
AGFI (Adjusted Goodness-of-fit Index)	0.718	0.723	0.767	0.687	0.694	> 0.85	Jöreskog, & Sörbom (1993),

TLI (Tucker Lewis Index)	0.910	0.917	0.931	0.902	0.909	> 0.90	Brown (2006)
NFI (Normed Fit Index):	0.871	0.867	0.891	0.853	0.86	> 0.90	Jöreskog, & Sörbom (1993),
CFI (Comparative Fit Index)	0.918	0.925	0.937	0.909	0.917	> 0.90	Brown (2006)
Parsimonious Measure							
(χ2/gl)	2.533	2.294	2.213	2.357	2.24	2 - 5	Wheaton et al., 1977; Tabachnick and Fidell, 2007.
PGFI higher than 6	0.656	0.659	0.695	0.643	0.646	> 0.50	Mulaik et al. 1989

Source: Research data.

CONCLUSION

The model that fits better to the context and to the literature review findings is composed by four factors considered as inducers of organizational innovation: 1) PD&I Management; 2) Leadership to Innovation; 3) Innovation Culture and 4) Oriented Strategy for Innovation. The first refers to a group of activities, from the applied research for the development of new products and services, including the management of ideas from users, suppliers and employees; the development and absorption of skills from suppliers, clients and users-citizens.

The aspect "Leadership for Innovation" deals with the capacity of organizational managers to lead changes, search for solutions and develop partnerships.

The factor "Innovation Culture" involves variables that describe the functioning of the organization, the relation of teams, the observable behaviors, promotion policies, perceptions of resistance to the new and the flexibility of working hours to learning, aiming to form and intensify required skills from organization strategies.

The factor "Oriented Strategy for Innovation" indicates the mid and long-term planning of innovation activities associated to the chain value of the organization, considering the adoption of practices of: monitoring the external environment; adoption of external comparative references and development and acquisition of skills that are essential to the organization.

Some variables used to test the innovation orientation model presented distributions with moderate deviation from normality, although a robust statistical technique for the normality hypothesis had been used. These restrictions are common in research of the organization field and do not invalidate the investigation, methods and results. Another limitation to the search is the fact that an intentional (not probabilistic) sample was used, with only 19 Brazilian companies, without statistical characterization of expansion.

The validation of the scale used revealed reliable psychometric indexes to conduct other empirical investigations. Under the methodological aspect, in turn, considering the relative scarcity of empirical studies about innovation, especially with organizations in the public sector, as shown in the documentary analysis, the research brings contributions, relating qualitative and quantitative techniques theoretically, methodologically and practical for this field of investigation.

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